POR-2506
(WT-2506)

Operation

ROLLER COASTER

PROJECT OFFICERS REPORT—PROJECT 2.6a

SPECIAL PARTICULATE CHARACTERISTICS

R. K. Fuller, Project Officer

J. D. O'Connor
M. J. Nuckolls

U. S. Naval Radiological
Defense Laboratory
San Francisco, California 94135

Issuance Date: November 10, 1965

[redacted]

POR-2506
(V.T-2506)

OPERATION ROLLER COASTER

PROJECT OFFICERS REPORT—PROJECT 2.6a

SPECIAL PARTICULATE CHARACTERISTICS

R. K. Fuller, Project Officer
J. D. O'Connor
M. J. Nuckolls

U. S. Naval Radiological
Defense Laboratory
San Francisco, California 94135

DEPARTMENT OF DEFENSE
Washington, D.C. 20301

ATOMIC ENERGY COMMISSION
Washington, D.C. 20545

ATOMIC WEAPONS RESEARCH ESTABLISHMENT
Aldermaston, Berkshire, England

[redacted]

[redacted]

ABSTRACT

Some physical and chemical properties of fallout resulting from the high-explosive detonations of nuclear weapons containing plutonium were determined. They included:

(1) The total mass of fallout collected per unit area.

(2) The amount of plutonium and uranium collected per unit area.

(3) The mass distribution of plutonium and uranium by particle size.

(4) The relationships among mass, plutonium content, and density of fallout samples.

(5) The solubility of plutonium under conditions associated with the radiological recovery of contaminated facilities.

The particulate fallout samples from the Double Tracks, Clean Slate I, and Clean Slate II events (DT, CS I, and CS II) were collected on 4-foot-square, petrolatum-coated, aluminum sheets placed upon the ground. They were distributed in a pattern downwind of the detonation point at distances ranging from 100 to 10,000 feet. After removal from the collector panels by a xylene rinse, the particulate was separated by centrifugation. The following data were then obtained: (1) combined gamma and X-ray activity as measured in a well-type NaI crystal counter, (2) total sample weight, (3) mass versus particle size, and (4) activity versus particle size. The plutonium content of each sample was computed from the counting data. (Am^{241}, a concomitant of reactor-generated plutonium, yields a 60-kev gamma ray, and Pu^{239} yields a 17-kev X-ray.)

At the U.S. Naval Radiological Defense Laboratory (NRDL) the plutonium content of samples was measured in two ways. One was by comparing the gamma count rates with calibration standards made from a sample of the plutonium used to fabricate the Roller Coaster (RC) devices. The second was by comparing gamma and X-ray spectra of samples with those of known RC plutonium standards. The plutonium content of a few samples was determined by resolving and comparing photopeaks of fissio. oducts, induced by neutron irradiation, with those induced in standards. Another method was radiochemical analysis done by Project 5.2/5.3 contractors. Comparisons of the averaged plutonium results obtained by each method agreed within ± 20 percent.

The amount of material collected ranged from 0.2 to 6.6 g/m^2 for DT, 0.2 to 28 g/m^2 for CS I, and 0.3 to 2,560 g/m^2 for CS II. In some cases, an unknown amount of desert

soil was blown onto the collectors, making precise measurements of the amount of fallout deposited on each collector impossible.

The amount of plutonium deposited ranged from 0.5 to 1,116 $\mu g/m^2$ for DT, [illegible] to 2,042 $\mu g/m^2$ for CS I, and 3 to 4,670 $\mu g/m^2$ for CS II.

The ratio of uranium to plutonium in unsieved fallout samples was close to that of the original ratio of the weights of the metal used to fabricate the RC devices. The ratio for different particle sizes in sieved samples was not constant, indicating fractionation of plutonium and uranium with particle size.

Of the plutonium in unsieved samples, 1 to 27 percent was associated with very fine particles having a density greater than 4.30; this fraction represented less than 5 percent of the sample weight.

A fallout sample from the 5,000-foot arc from each of the first three events was wet-sieved. Fifty percent of the gamma activity was associated with particles less than 84μ for DT, 195μ for CS I, and 39μ for CS II. In fact, 98 percent of the gamma activity was associated with particles less than 50μ in the CS II sample. There was a general, but not always consistent, decrease in the particle size of samples collected at increasing downwind distances.

Leaching and ion exchange studies showed that the plutonium in the fallout was not dissolved by water alone or water solutions of sodium hydroxide and Orvus. About 10 percent was dissolved by 0.1 N hydrochloric acid, however. When fallout was mixed and allowed to stand with a water slurry of montmorillonite clay, about 6 percent of the activity became associated with the clay.

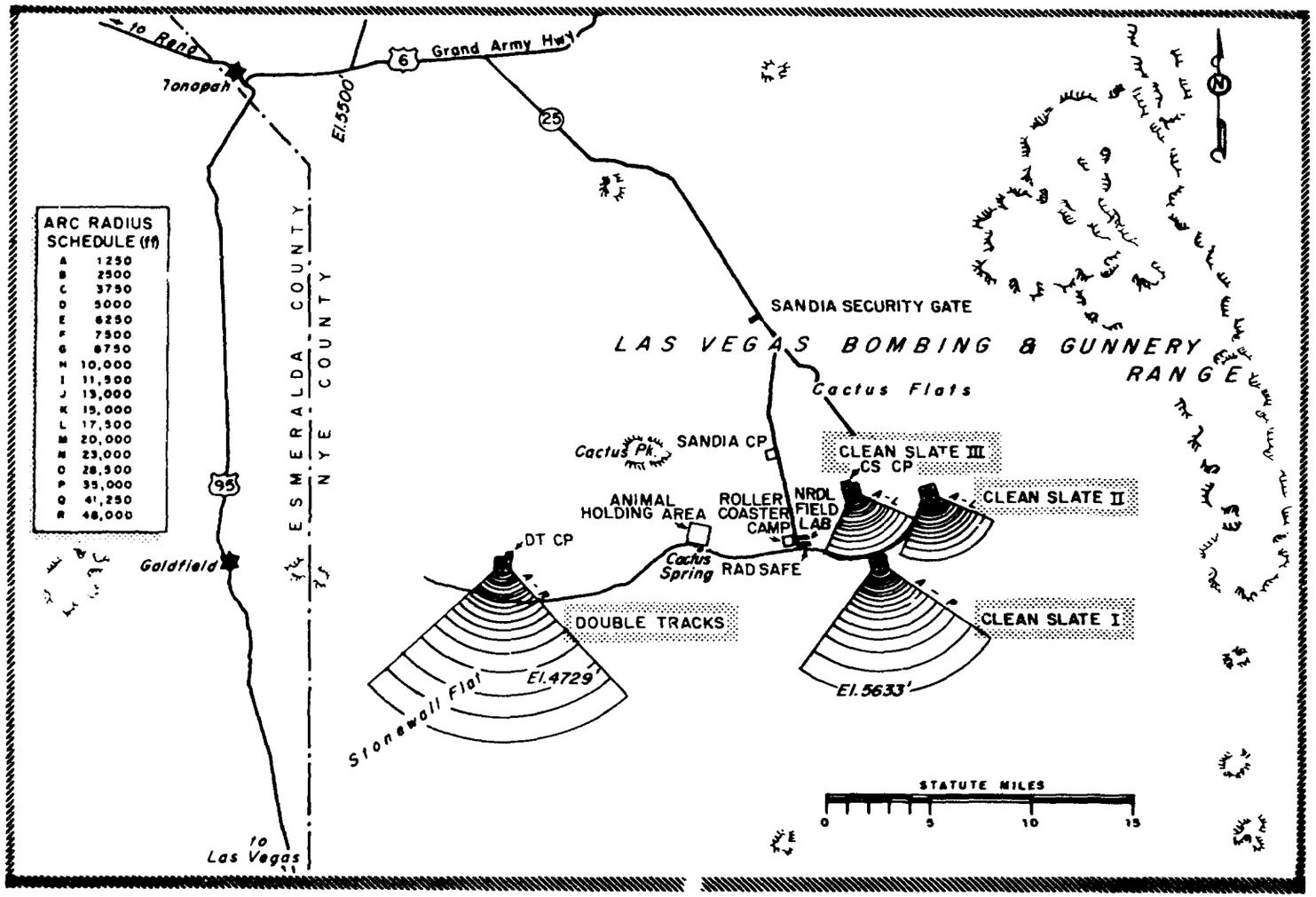

Figure 1.1 Roller Coaster site layout.

TABLE 2.1 WEATHER DATA AT SHOT TIMES

Event	Time	Date	Wind Speed at GZ	Wind Shear	Temperature Inversion
			(knots)	(degrees)	(°C)
Double Tracks	0255	15 May 1963	11	25	2.5 at 500 ft
Clean Slate I	0417	25 May 1963	12	almost none	5 at 600 ft
Clean Slate II	0347	31 May 1963	6	40	2 at 500 ft

TABLE 2.2 RESPONSE OF GAMMA COUNTER AT TTR TO NON-ROLLER COASTER PLUTONIUM STANDARD

	Response		
	DT	CS I	CS II
105 μg Pu^{239} (cpm per μg of Pu^{239})	900	886	944
Background (cpm)	1,020	1,060	1,050

TABLE 2.5 ANALYTICAL[a] AND OTHER PERTINENT DATA ON ROLLER COASTER URANIUM AND PLUTONIUM SAMPLES

Isotopic Analysis of Plutonium Sample sent to NRDL (Batch Number 63-UK-103-RC)	Pu^{238}[b] (Wt %)		Am^{241}[c] (Wt %)		$Pu^{239-240}$[b][c] (Wt %)
	0.0040		0.0234		> 99
Chemical Analysis of Plutonium Sample sent to NRDL	Plutonium (g Pu/g of metal sample)				
	0.9883				
Mass Spectrometric Analysis of Plutonium sample sent to NRDL (atomic percent)	238	239	240	241	242
	0.00	97.35	2.42	0.13	0.00
Isotopic Analysis of Uranium	U^{234}[b] (Wt %)		U^{235}[c] (Wt %)		U^{238}[b] (Wt %)
	< 0.001		0.21		99
	< 0.001		0.22		99
Mass Spectrometric Analysis of Uranium (atomic percent)	U^{235}		U^{238}		
	0.17		99.83		
	0.15		99.85		

	Double Tracks	Clean Slate No. 1	Clean Slate No. 2
Ratio of Uranium to Plutonium (by weight)[d]			
Ratio of Pu^{239} to U^{235}	4.35	47.2	100.4
	24:1	11:1	5:1

(a) Analytical data obtained from Reference 10. Data declassified by message from Commander, Field Command, DASA, to Roller Coaster personnel, message No. 031612Z, dated 3 February 1963. Americium determination made on 1 May 1965.

(b) By alpha spectrometry.

(c) By gamma spectrometry.

(d) Unclassified uranium to plutonium weight ratios originally sent by Commander, Field Command, DASA, to Roller Coaster personnel, message No. 280003Z, dated 28 July 1964. These ratios, shown here, are modified somewhat from previous values and are quoted from a 19 January 1965 memo from H. E. Menker to the Roller Coaster Evaluation Team.

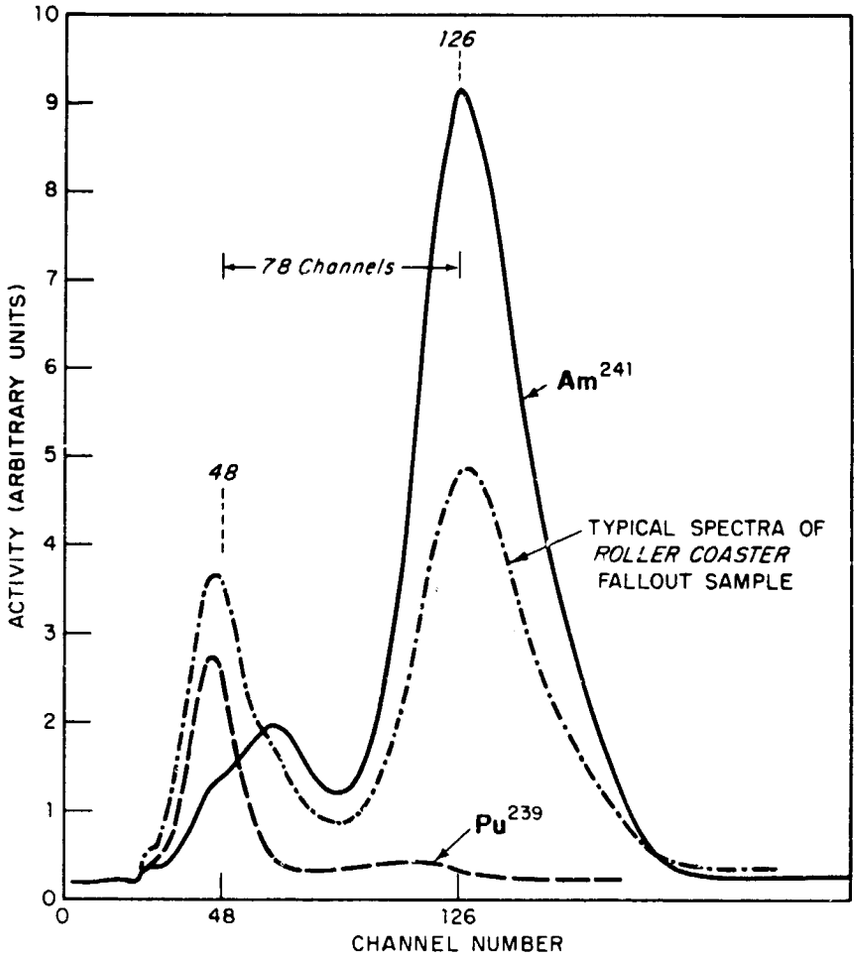

Figure 2.16 Typical gamma and X-ray spectra of purified Am^{241}, purified Pu^{239}, and Roller Coaster fallout.

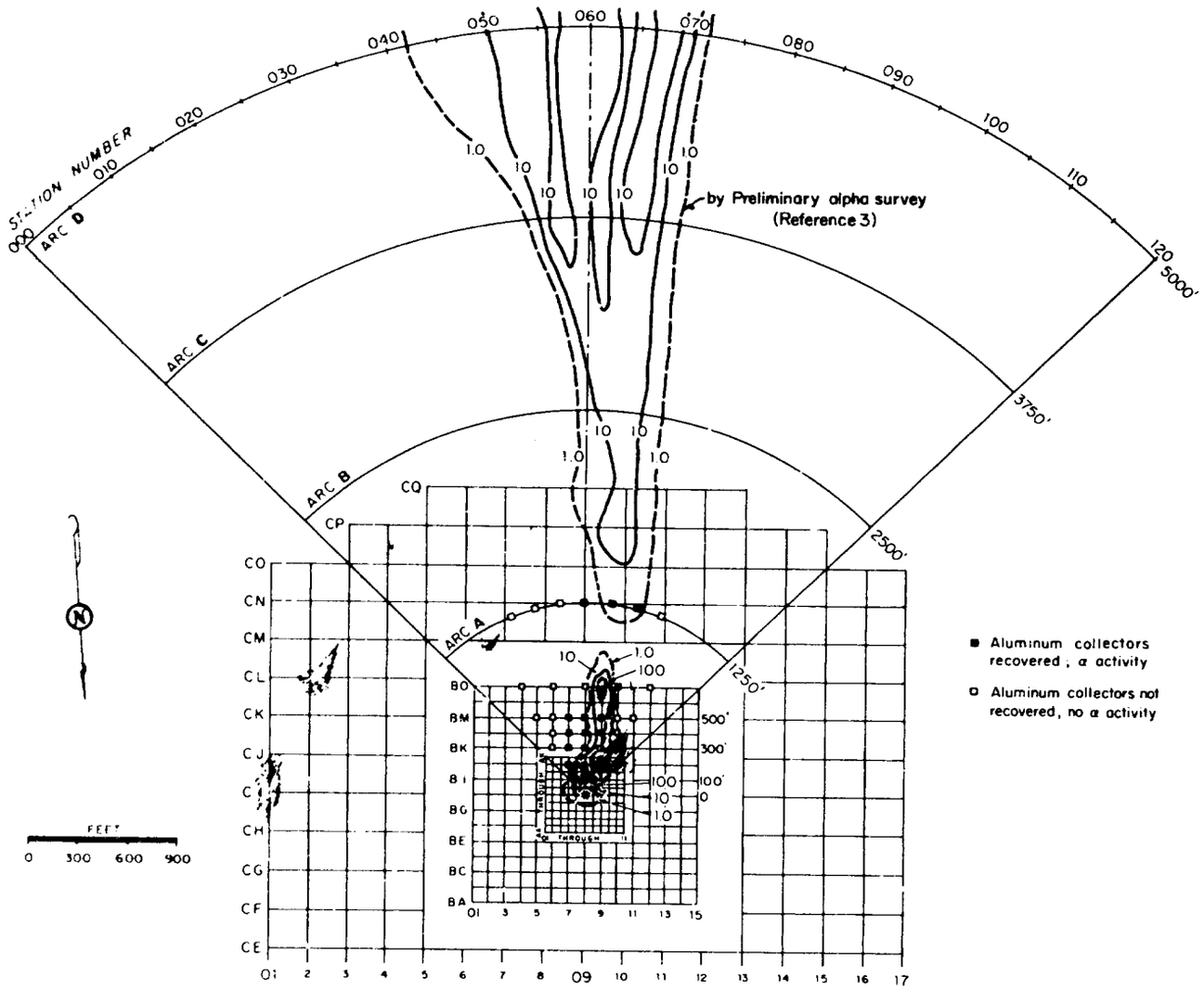

Figure 3.1(a) Location of aluminum collectors in downwind grid array, Double Tracks.

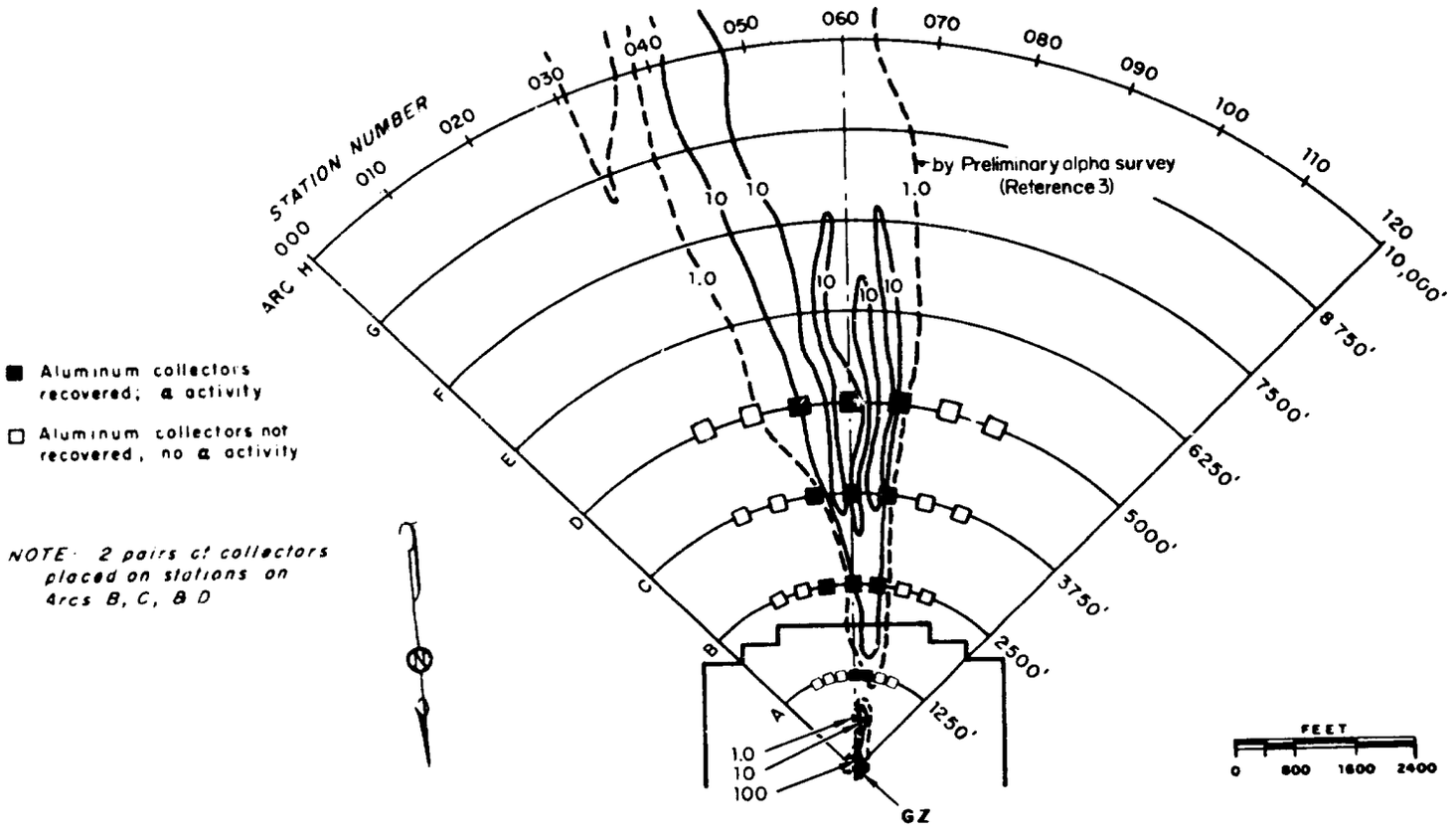

Figure 3.1(b) Location of aluminum collectors in downwind arc array, Double Tracks.

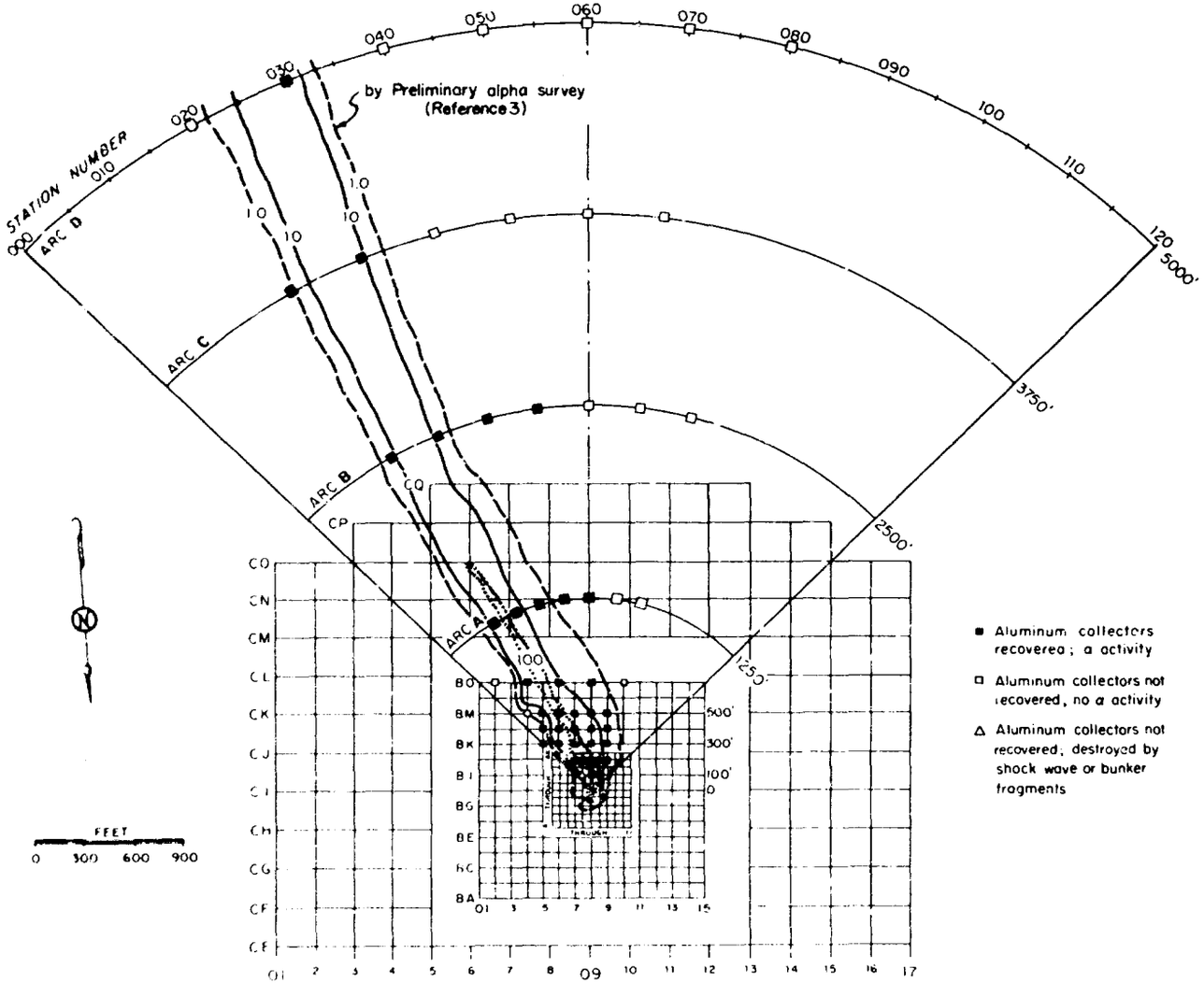

Figure 3.2(a) Location of aluminum collectors in downwind grid array, Clean Slate I.

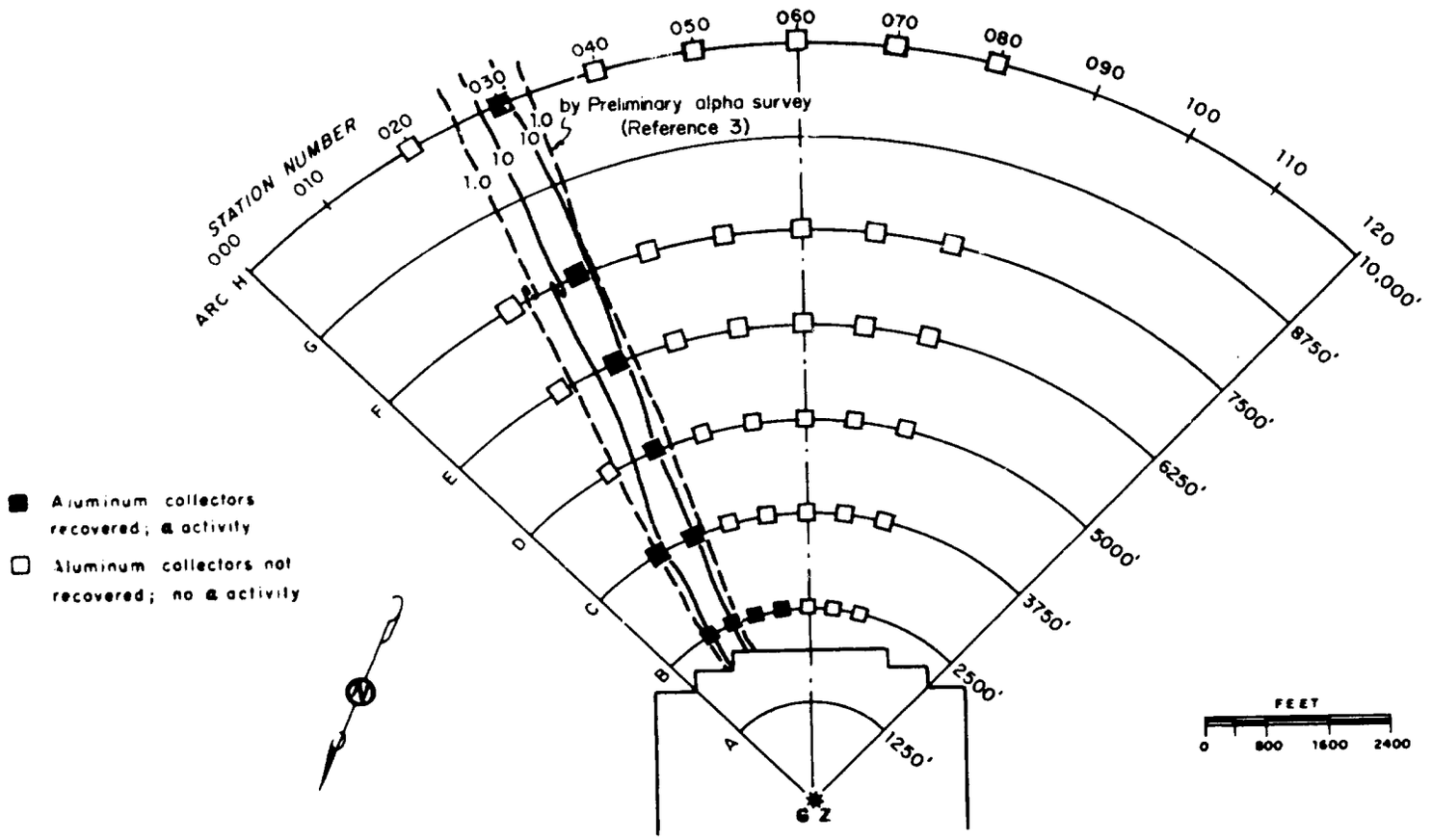

Figure 3.2(b) Location of aluminum collectors in downwind arc array, Clean Slate I.

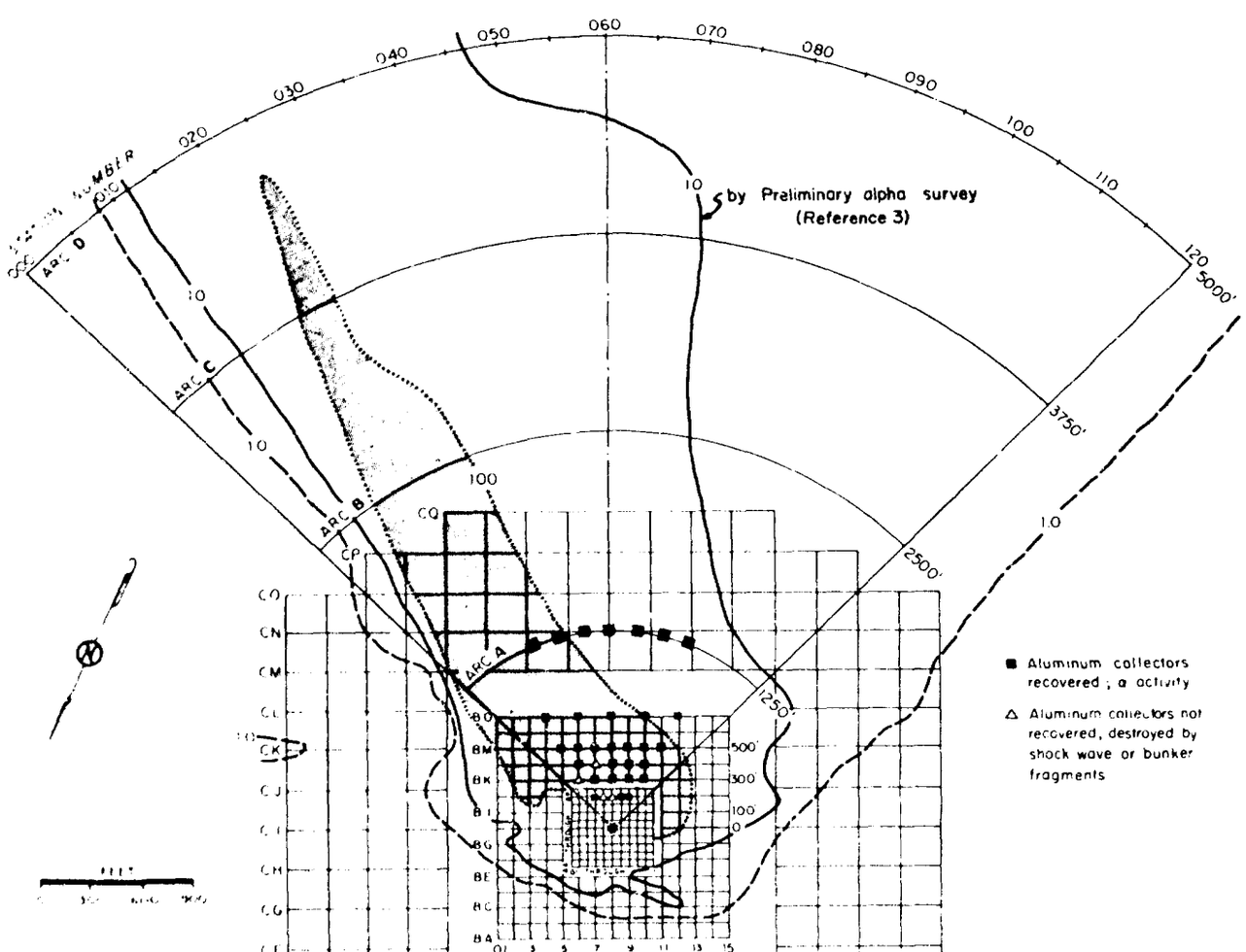

Figure 3.3(a) Location of aluminum collectors in downwind grid array, Clean Slate II.

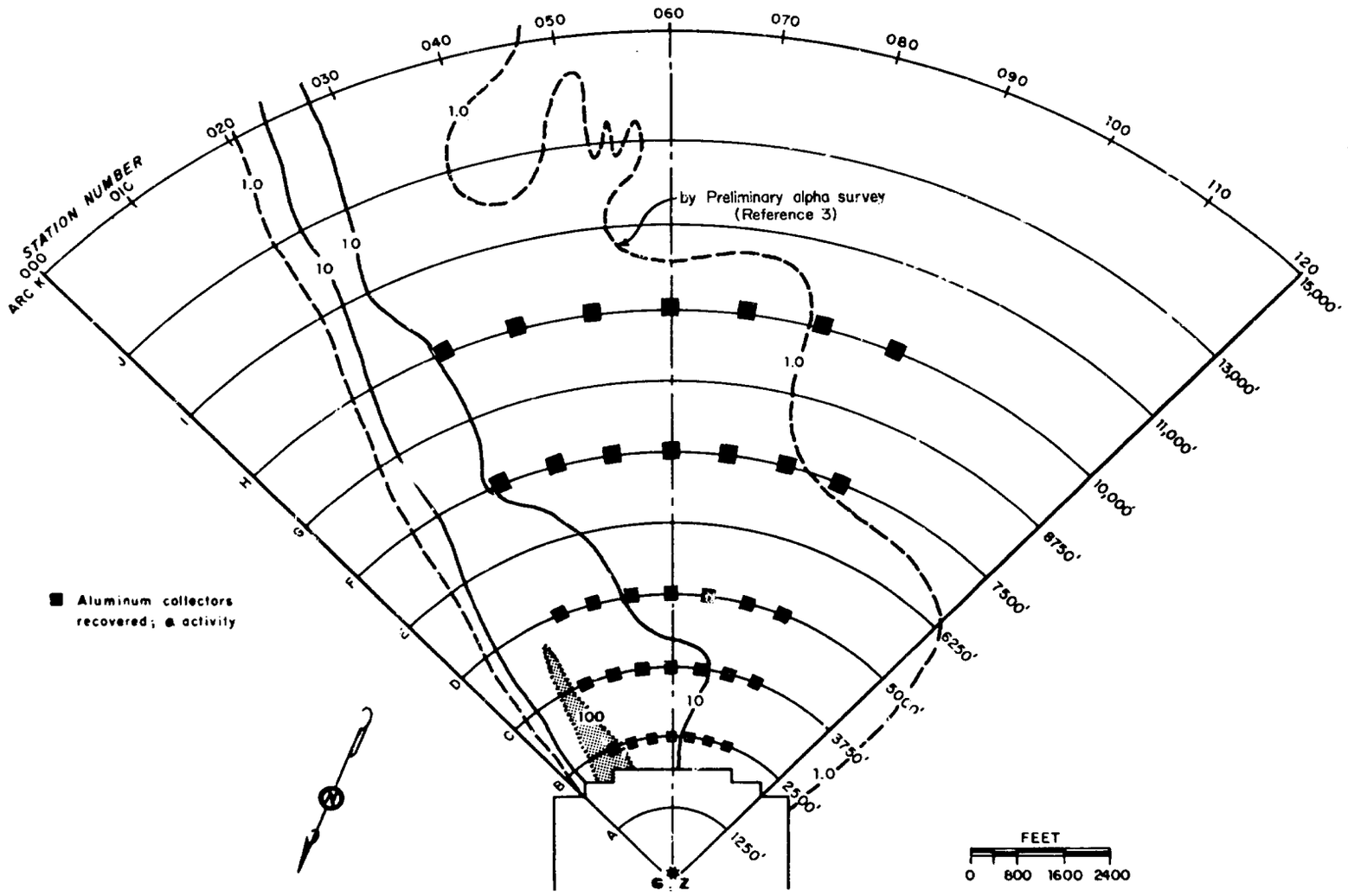

Figure 3.3(b) Location of aluminum collectors in downwind arc array, Clean Slate II.

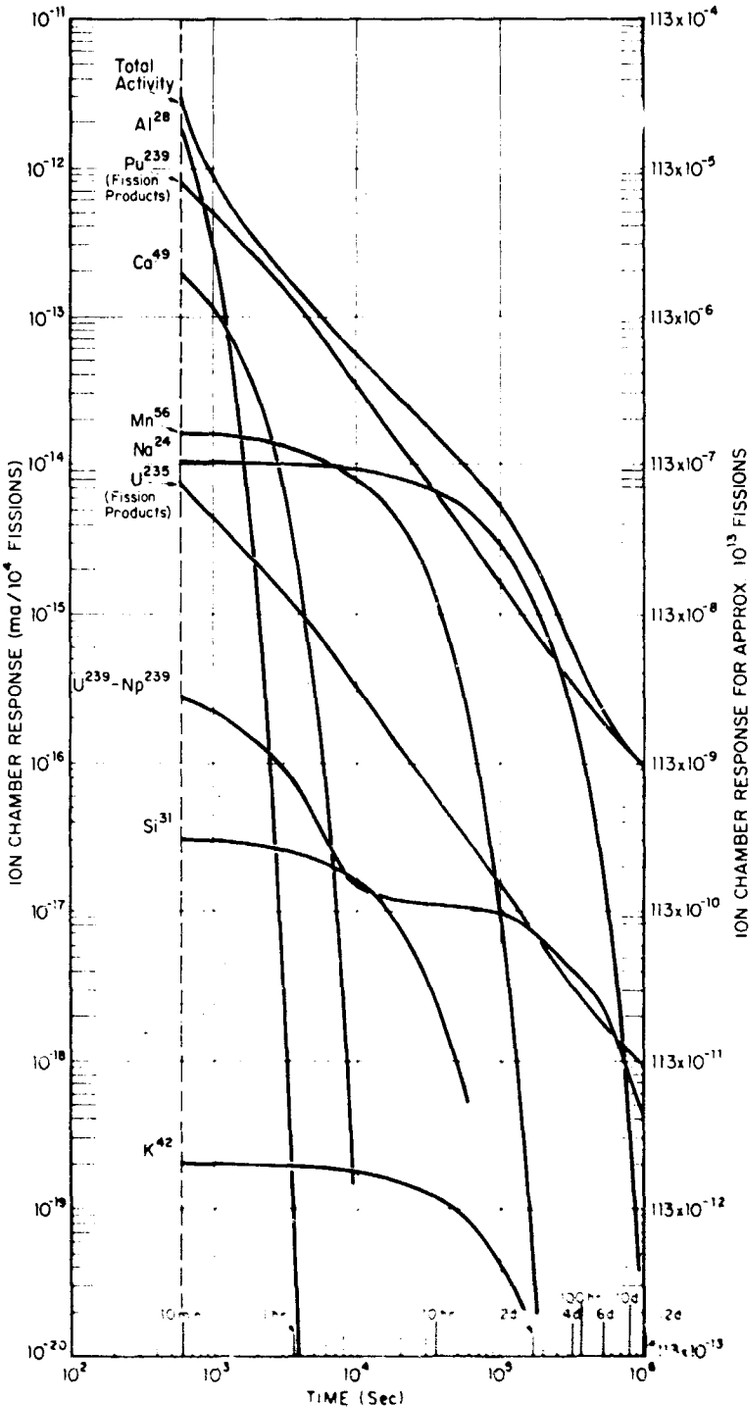

Figure B.1 Four-pi ionization chamber response to a hypothetical neutron-irradiated Double Tracks fallout sample.